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Pollution Prevention Opportunity Assessment for Building 878, Manufacturing Science and Technology, Organization 14100

Initial Data Gathering and Opportunity Identification

Kristin Klossner

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185

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Initial Data Gathering and Opportunity Identification

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Abstract

This report describes the methodology, analysis and conclusions of a preliminary assessment carried out for activities and operations at Sandia National Laboratories Building 878, Manufacturing Science and Technology, Organization 14100. The goal of this assessment is to evaluate processes being carried out within the building to determine ways to reduce waste generation and resource use. The ultimate purpose of this assessment is to analyze and prioritize processes within Building 878 for more in-depth assessments and to identify projects that can be implemented immediately.

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Executive Summary

This report was completed by the Sandia National Laboratories/New Mexico (SNL/NM) Pollution Prevention (P2) Program staff. The P2 program is part of SNL's Solid and Hazardous Waste Management Program, Organization 3124. P2 is tasked with assisting SNL organizations to reduce waste and improve overall efficiency of their operations. This study was conducted as part of a program of environmental improvements being undertaken for Manufacturing Science and Technology (Mfg S&T), Organization 14100 as part of their environmental management system (EMS).

This report completes the first two steps in a project that will be completed in the following four phases: 1) data gathering and analysis; 2) ranking and prioritization of waste reduction opportunities; and 3) further assessments and 4) implantation of waste reduction projects. This report provides a profile of organizations and operations in Building 878 and recommendations for further analysis. The final phase will entail an in-depth assessment of a selected organization within 14100 as well as implementation of smaller projects to reduce waste.

Information from 14100 staff was crucial in the development of the profiles for each organization. A member of the SNL P2 staff interviewed personnel and in some cases, toured labs in Building 878. During the interviews, participants were asked about their processes in the light of potential waste reduction opportunities. Most interviewees were very aware of cost and issues related to waste generation as well as other ES&H issues. Many organizations within 878 have developed excellent means to manage chemicals, reduce waste and improve their processes. These best practices were noted and have been included in this report.

A number of suggestions for waste reduction were identified during the interviews. In conjunction with the 14100 Environmental Management System (EMS) team, P2 staff analyzed these suggestions, focusing on potentials for waste reduction, cost savings and ease of implementation. One organization, 14153-2, the Plastics Lab, was identified for an individual assessment, known as a Pollution Prevention Opportunity Assessment (PPOA) which will be completed in 2004. The PPOA will follow a standard format developed by the Department of Energy and the Environmental Protection Agency and utilize a team approach to develop alternatives to reduce waste and improve efficiency.

Several waste reduction projects were identified by both the interviewees and the EMS team. Reports will be completed as these projects are implemented. Appendix 4 documents those processes that were assessed and how they were evaluated.

Acronyms and Abbreviations

3DP	Three Dimensional Printing
CIS	Chemical Information System
DI	Deionized
DOE	U.S. Department of Energy
EMS	Environmental Management System
EPA	U.S. Environmental Protection Agency
eTWD	Electronic Work Document
FY	Fiscal Year
JIT	Just-In-Time
MSDS	Material Safety Data Sheet
Mfg S&T	Manufacturing Science and Technology, Organization 14100
NGF	Neutron Generator Facility, Organization 14400
P2	Pollution Prevention
PPE	Personal Protective Equipment
PPOA	Pollution Prevention Opportunity Assessment
PZT	Lead zirconium titanate
RCRA	Resource Conservation and Recovery Act
ROI	Return on Investment
RPL	Manufacturing, Engineering and Process Development Laboratory
SL	Stereo Lithography
SLS	Selective Laser Sintering
SOP	Safe Operating Procedure
SNL/NM	Sandia National Laboratories/New Mexico
TCE	trichloroethylene
WIMS	Waste Information Management System
WR	Weapons Related

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1.0 Introduction and Methodology

The Pollution Prevention (P2) staff of Sandia National Laboratories (SNL) conducts pollution prevention opportunity assessments (PPOAs) for organizations within SNL. The goal of a PPOA is to identify practical, cost-effective strategies to do one or more of the following:

- Reduce the line organization's operational costs through improvements in efficiency
- Reduce overall resource use
- Reduce or eliminate the generation of waste
- Reduce waste volumes and toxicity
- Reduce energy and water consumption

The completed PPOA is presented to the organization for implementation. The P2 staff will assist with implementation as much as possible by providing technical and administrative support and seeking funding options when necessary.

P2 staff was tasked by Manufacturing Science and Technology (Mfg S&T), Organization 14100, to analyze operations in Building 878. This analysis is part of the implementation of an Environmental Management System (EMS) the goal of which is to reduce the financial and environmental impact of waste from Mfg S&T operations. The analysis included an evaluation of chemical purchasing and management, processes that generate waste, and energy and water use. Best practices and waste reduction suggestions and ideas were documented for each organization and for Building 878 as a whole. The goal of this report is to identify and prioritize processes for further research and identify projects that can be implemented immediately. The analysis will consist of four specific tasks, conducted during FY03 and FY04. Tasks 1 and 2 are the subject of this report. All tasks are identified below:

Task 1 Data Gathering and Analysis This task identifies chemical purchasing and management activities and quantifies the types and amounts of waste generated in Building 878. Using the SNL Waste Information Management System (WIMS) data base and knowledge of the Center's waste technician, waste generation was tracked to each organization and when possible to the specific generating process. Profiles were created for each organization that include chemical purchasing and waste generating activities.

Information from 14100 staff was crucial in the development of the profiles for each organization. A member of the SNL P2 staff interviewed personnel and in some cases, toured labs in Building 878. During the interviews, participants were asked about their processes in the light of potential waste reduction opportunities. Most interviewees were very aware of cost and issues related to waste generation as well as other ES&H issues. Many organizations within 878 have developed excellent means to manage chemicals, reduce waste and improve their processes. These best practices were noted and have been included in this report.

Task 2 Ranking and Prioritization This task identifies further assessments to be conducted and projects to be implanted. A number of alternatives for waste reduction were identified during the interviews with 14100 personnel. Alternatives were analyzed by the Center Environmental Management System (EMS) team. The task of this team, created in 2001, to help is to implement environmental management practices including waste reduction and energy savings throughout the Organization 14100. The team includes the ES&H coordinator, two Industrial Hygienists, a Facilities building representative, the Hazardous Waste Technician and a member of the P2 staff. This group analyzed the potential opportunities and ranked them based on the following criteria:

- Return on investment
- Waste generation rates
- Ease of implementation
- Potential for reducing waste
- Potential for improvements in efficiency
- Potential for water and energy conservation

Task 3 Conduct individual Pollution Prevention Opportunity Assessments (PPOAs) (FY04). The ranking and prioritization analysis identified one organization, 14153-2, the Plastics Lab, for an individual assessment, known as a Pollution Prevention Opportunity Assessment (PPOA) which will be completed in 2004. This assessment involves more in-depth research and cost/benefit analyses to determine the potential return on investment of new equipment and process enhancements. The PPOA will follow a standard format developed by the Department of Energy and the Environmental Protection Agency and utilize a team approach to develop alternatives to reduce waste and improve efficiency.

Figure 1 is a flow diagram that outlines in steps the PPOA process. This process will be applied to the individual assessment identified in this report. Implementation of recommended changes is dependent on available budget and resources and will be determined by SNL Management.

Task 4 Implement Waste Reduction Projects (FY04-05). A number of waste reduction projects were identified in this report. The team evaluated these projects and categorized them by two criteria. The first category includes projects where enough information is known now to implement them immediately. The others are projects considered worthy of implementation but that require further study and a feasibility analysis before implementation. An implementation report will be completed for each project. Appendix 4 lists the identified projects as well as their evaluations.

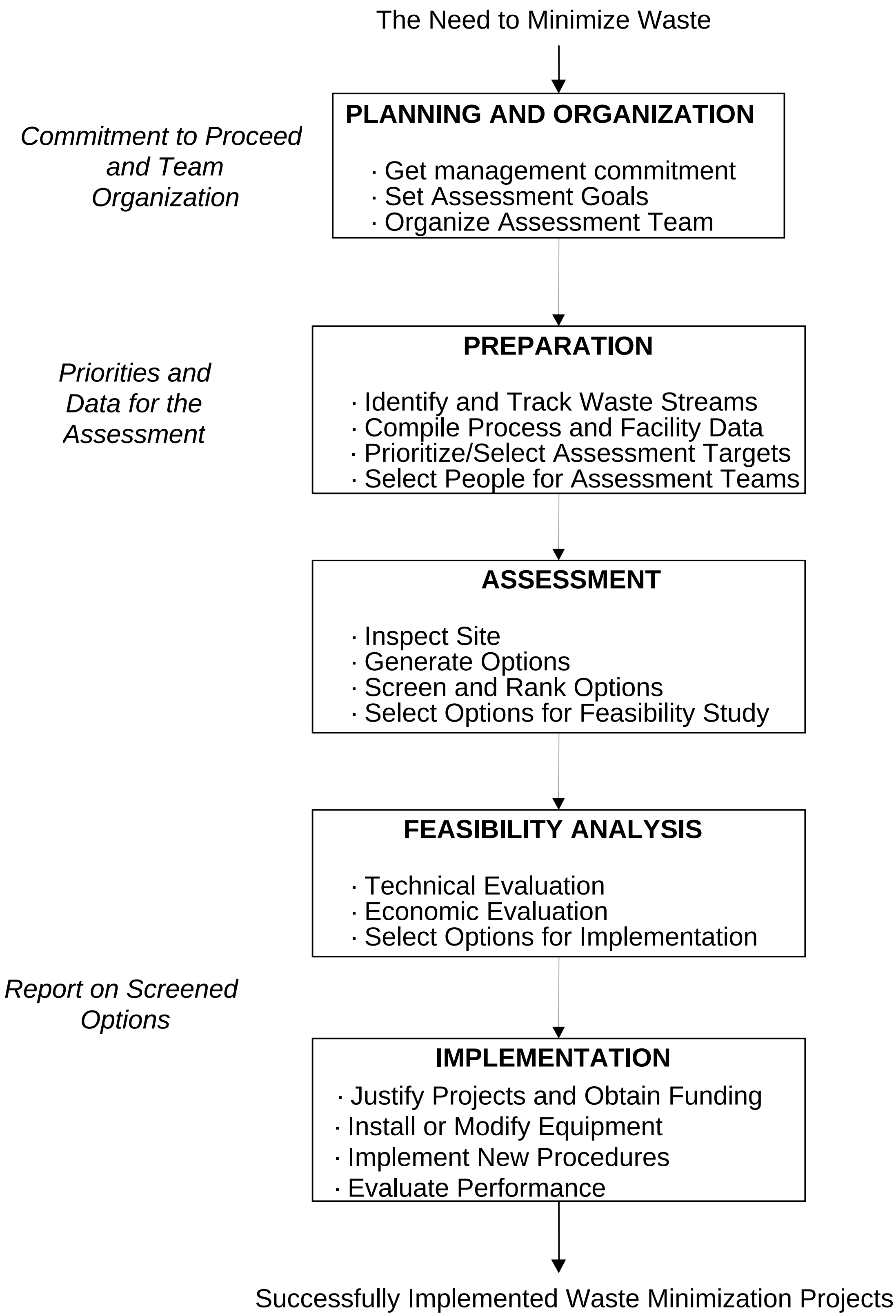

Figure 1 Pollution Prevention Opportunity Assessment Process

2.0 Facility Description

Mfg S&T, Center 14100 is located at SNL. Sandia is a national security laboratory operated for the U.S. Department of Energy (DOE) by the Sandia Corporation, a Lockheed Martin company. SNL designs non-nuclear components for the nation's nuclear weapons, performs a wide variety of energy research and development projects, and works on assignments that respond to national security threats both military and economic.

Mfg S&T is a complex organization consisting of several departments dispersed throughout four buildings. Building 878 is the focus of this report. It houses a number of activities and contains approximately 75 different laboratories in which numerous and varied processes are carried out. The main waste generating processes undertaken here include synthesis of organic materials, mechanical engineering, thin film and vacuum packaging, manufacturing processing, electronic fabrication, and research and development (R&D) services for ceramics and glass.

Figure 2 shows quantities of waste generated by SNL division. The Division 14000 (14100's parent organization) consistently generates the largest or second highest quantity of hazardous waste at SNL. Center 14100's waste makes up approximately 65% of the waste generated by Division 14000; therefore the Center alone is a larger generator than most divisions. The Center's overall waste costs have averaged $300,000 annually over the last three years. These high costs as well of the stigma of being the one of the largest generators have driven the Center to implement a number of waste reduction initiatives. This PPOA is one of them.

Though the basic processes are unchanging, there is tremendous flexibility in the types of materials used as well as levels of product output. There is also a strong focus on R&D. This flexibility and R&D focus presents more of a challenge than might be faced in typical manufacturing organizations, where environmental parameters such as waste streams and energy use are more consistent. Activities associated with creation of prototypes can be more easily predicted than those associated with R&D and therefore can be easier to control and manage. Each department within the Center is described in Section 5.

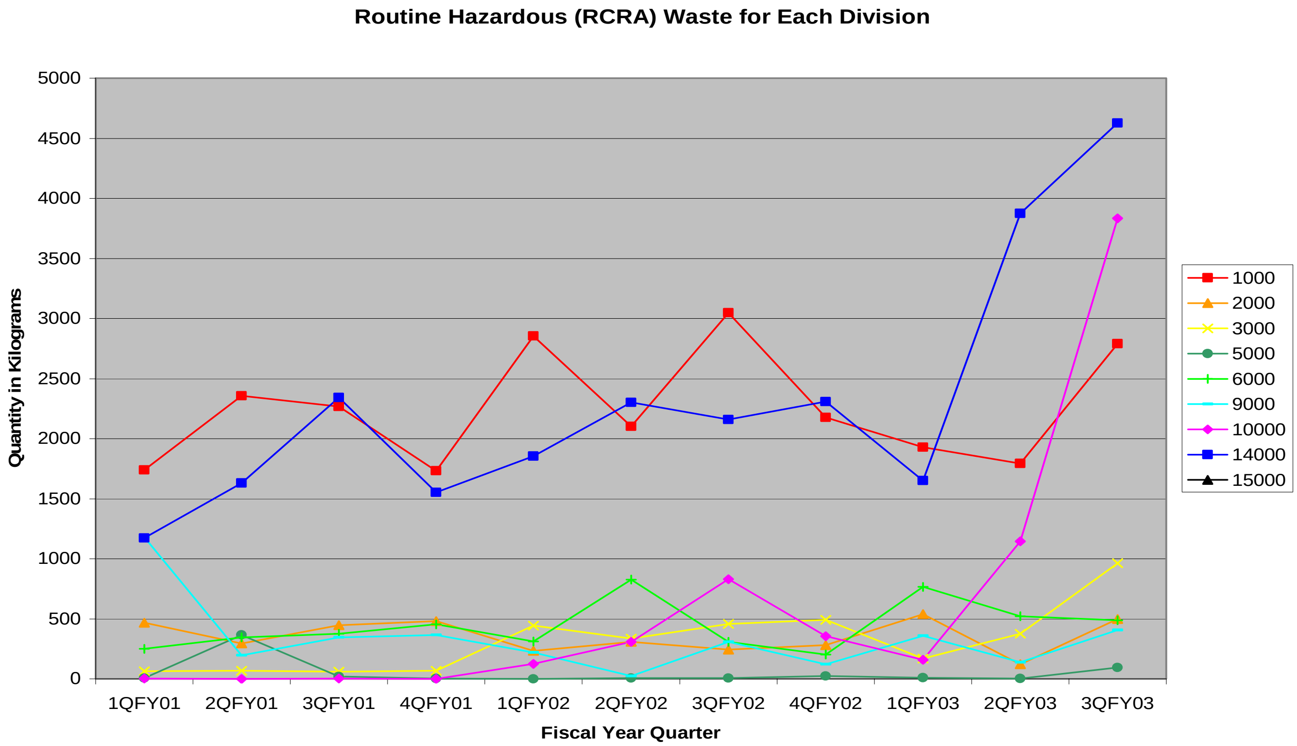

Figure 2 Comparison of SNL Division Hazardous Waste Generation

3.0 Waste Management Overview

Center 14100 has recently implemented new waste management practices that have resulted in significant reduction of disposal costs. These include: bulking similar wastes to decrease disposal charges; profiling waste to solid waste which means labeling waste streams that were conservatively considered hazardous and disposing them as non-hazardous; compacting lab trash and utilizing the Hazardous Waste Technician to find users for unused chemicals. See Appendix 1 for further details.

SNL tracks wastes through the WIMS database. This data base tracks, among other things, the generating organization, the description of the waste, the quantity and volume of waste in kilograms and the approximate charge for disposal. This database allows in-depth analysis of wastes generated by any organization. The charges for waste disposal vary from $0.40 to $60.00 per kilogram depending upon the volume and types of waste. Additional costs are added as overhead by various organizations. Waste costs included in this report are estimated based upon the standard disposal costs and may not reflect actual charges.

Waste can easily be tracked to the Department level within Center 14100. Figure 3 shows the cost of wastes generated by department for the last three years. However, to develop a more complete analysis of waste streams, it is necessary to identify waste streams on the process level. In order to do this, personnel who are most familiar with their organization's waste streams were identified and interviewed. These interviews make up the basis for this report. In order to minimize disruption of work time, the interviews were kept to a time limit of one hour with a phone or email follow up.

During the interviews and evaluations of each organization, recommendations regarding process enhancements were developed that would apply specifically to those organizations. These are included in Section 5. Other recommendations were developed to improve waste management for the Center as a whole. This list was evaluated for feasibility by a team of subject matter experts including Industrial Hygienists, Waste Management Specialists and the Facility ES&H Coordinator. Those judged desirable to implement are summarized in the following paragraph. A table summarizing the evaluations and documenting why some suggestions were deemed unfeasible is included in Appendix 4. In some cases, the opportunity for an additional PPOA was identified as was the need for further research prior to implementation. These opportunities are also in included in the appendix.

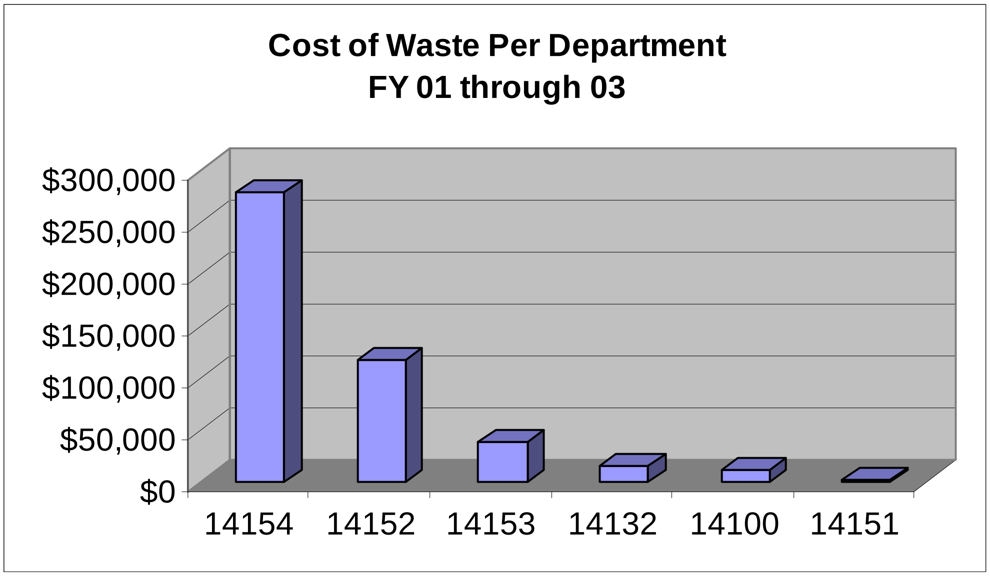

Figure 3 Cost of Waste

3.1 General Recommendations for Enhancements to Waste Reduction

- Neutralize corrosive wastes and dispose neutralized liquid in the sanitary sewer. This option has been studied in the past and was found to be problematic for a number of reasons. Often the wastes contain metals such as copper and zinc. These would prevent disposal in the sanitary sewer without further treatment such as precipitation and removal of the metals. This was deemed to be too time consuming by lab personnel. Many of these waste streams are extremely corrosive and may not be amenable to neutralization due to hazards associated with this process. An analysis of each waste stream will be completed to determine the feasibility of neutralization on a case by case basis.

- Characterize recurring waste streams using laboratory analysis, particularly those waste streams involving PZT powder, green tape and slugs. It is conservatively assumed that these waste streams are hazardous. Proper characterization may allow disposal of a number of waste streams as non-hazardous.

- Replace mercury-containing thermometers with digital or alcohol/glycol thermometers. Mercury has become extremely expensive to manage and dispose. A mercury spill can cost thousands of dollars in clean up and disposal costs because of the regulatory requirements required when handling mercury. For differential manometers, use water or calibrated oils instead of mercury or switch to pressure transducers or electronic pressure gauges. This has already been accomplished in all the research labs within Organization 1800.

- Evaluate all processes using solvents for cleaning to determine if pollution prevention measures such as filtration, distillation or aqueous-based ultrasonic cleaning could be applicable. This evaluation would be on a case-by-case basis.

- Track waste by process i.e., lab, and send monthly chargeback reports showing the costs of waste to the lab owners. This will allow a better understanding of the true costs of a process. Create measurable goals for waste reduction for each process and develop a plan to achieve them

- In most of the Center's organizations, waste is considered an overhead cost and is not accounted for when considering cost estimates to customers. Accurately predicting waste costs for each job and passing them to customers could decrease overhead costs for the Center and thereby increase competitiveness. This type of cost allocation program could allow the Center to better determine the cost of serving each customer so that prices reflect true costs more clearly. Implementation of this kind of cost accounting must be evaluated for effectiveness. A pilot study with one organization is suggested.

- Include a process diagram and appropriate pollution prevention guidelines in each organization's Safe Operating Procedures (SOP's) and Electronic Work Documents (eTWD's). This should include a general description including constituents and volumes of wastes from each process. Any new processes, wastes or process changes would require a change to this documentation. This type of evaluation and documentation is consistent with SNL's proposed method of meeting the requirements to have an EMS in place by 2005.

- Develop 20 minute training sessions for each lab to discuss chemical management, waste management and pollution prevention. To be effective this training must be lab specific. It could be similar to the existing training known as ENV 112 Spec and should be required at least twice a year or whenever issues are identified that need to be addressed. Develop mandatory, special training for all new-hires, students and temporary lab occupants. Ensure employees are aware of the true cost of managing and disposing chemicals. Keep a log of non-conforming waste disposal from each lab and have these incorporated into training. Improve labeling, signage and training in all labs to reduce errors in incorrect disposal of wastes. See Appendix 3 for an example of such training

4.0 Chemical Management Overview

Chemical management is particularly important for organizations within Building 878. According to inventory records from July of 2003, there were over 2000 different chemicals stored in Building 878. Because of stringent management and training requirements regarding chemicals, one study estimates the cost to manage chemicals to be 3 to 5 times the cost of purchase. This hidden cost of chemical management is often not accounted for in budget planning and so can become an unpleasant surprise expense and excessive burden to an organization whose goal is to keep service costs competitive.

The second largest waste stream from Building 878 consists of unused chemicals. For this report, unused chemicals from all organizations were combined to form one waste stream. These chemicals may have exceeded shelf-life and become unusable or were purchased for a process that was discontinued. In 2003, many chemicals were disposed in a clean-out prior to an audit in January. Many labs have taken advantage of the convenient services of the new Waste Management Technician hired for the Center and, with his help, disposed of old material that they may not have had time to dispose of themselves. The overall cost to the Center for disposal of these chemicals was over $40,000. At this point, it is crucial to implement new procedures to prevent a build up of such unusable chemicals in the future. A variety of supply chain management and inventory control procedures could be instituted to improve the efficiency of chemical management in Building 878. A number of labs have already instituted such procedures. These are outlined in Section 5.0.

All chemicals at SNL are tracked through the Chemical Information System (CIS) data base. Most chemicals are purchased through the SNL Just-In-Time (JIT) contract with Fisher Chemical Company. The contract requires Fisher to barcode all chemicals so that the end user can enter the barcode into the CIS when it arrives at 878. This information goes into the database which shows the volume of the chemical container, the lab and the owner. When the container is empty, its barcode is removed from the system by the user before the container is disposed. Although the CIS provides a basic inventory system for chemicals, it has two major limitations. First, it does not track actual quantities used. The chemical container is considered full until it is empty. In other words, once the chemical is bar-coded into the system, no other data is available until the container is disposed. This does not provide adequate inventory control data that would allow users to track actual quantities on hand. Second, no information is available regarding shelf life. This is another important factor in management of chemicals that should be addressed through other means.

Although most chemicals are purchased through the Fisher contract, there are some exceptions. These include those purchases through Bonded Stores (see discussion in the following paragraph) and those that are not available or are too expensive through Fisher. In most cases, end-users barcode these non-contract chemicals when they arrive, although this doesn't always occur. Storing chemicals with no barcodes is an important safety issue since the Center is required to know the types and quantities of chemicals located in its buildings. This information is used by a variety of subject matter experts including industrial hygienists, safety personnel and waste management personnel to safely and legally manage hazards within Building 878.

A number of processes have special quality requirements for chemical purity. Chemicals used in these processes must be purchased from Bonded Stores which resides in Organization 14409-1, Materials and Value Stream, part of Organization 14400, the Neutron Generator Facility (NGF). Bonded Stores is charged with providing quality approved material for weapons-related (WR) manufacturing. Each batch of material received from the manufacturer must be sampled and analyzed to ensure that it meets minimum quality requirements. Bonded Stores uses an inventory control system which monitors consumption using pre-determined minimum and maximum material counts to ensure materials are available. Those who use chemicals from Bonded Stores are required to monitor chemicals for the shelf-life that is marked on the label.

The process used to evaluate waste management (described in Section 3) was also used to evaluate chemical management. Recommendations regarding chemical management were developed both for each organization (Section 5) and for the Center as a whole. Those that were judged desirable to implement are included below. A table summarizing the evaluations and documenting why some suggestions were deemed unfeasible is included in Appendix 4.

4.1 General Recommendations for Enhancements to Chemical Management

- Institute a centralized ordering and receiving system for chemicals. This recommendation would require the Hazardous Waste Technician to order, receive, barcode and deliver all chemicals for 878 including samples and non-Fisher items. This would ensure that all chemicals are properly barcoded and tracked. It would also allow inspection of materials upon delivery, and the immediate return of unacceptable materials to the supplier.

- Identify common chemicals such as propanol, methanol, acids, bases, and acetone that do not have specific quality requirements for storage and handling. Store them in bulk and have them delivered on request by the Waste Management Technician. Buying in bulk would reduce the purchase price of chemicals, improve availability and improve chemical tracking. Users would be charged a per liter or ounce rate based on a cheaper bulk cost of that chemical. Consider adding a dedicated chemical and waste management storage unit for this purpose.

- Eliminate the purchase and use of aerosol cans wherever possible. In many cases aerosol nozzles fail, leaving material in the can. The purchase cost of the contents in the can is also more expensive than similar materials not in aerosol form. Refillable aerosol containers reduce disposal cost and purchase cost since material can be purchased in bulk. See Appendix 2.

- Consider consolidating chemicals by limiting brands wherever possible. For example, numerous different types of epoxies are used. By compiling a list of epoxies and their performance requirements, one brand that works for many purposes could be identified. Different brands that serve the same purpose could be eliminated thereby providing improved efficiency and purchase prices through standardization.

- Disposal of unused chemicals is particularly expensive. There is a cost from the lost use of the material as well as a disposal cost. It is recommended that the Center track monthly disposal of used chemicals to bring attention to this issue. When the true cost of disposing of these chemicals is determined, it may become clear that more effective inventory control measures would be feasible.

- Require purchasers to notify the ES&H coordinator when new chemicals or samples are brought into the building.

- Consider adding shelf life to all chemical labels and implementing a tracking system that flags all chemicals that are about to exceed shelf life. Add the purchase date to each container label and adopt a "first in, first out" policy so that older materials are used up before new ones are opened. This is already being done in the Plastics Lab (Organization 14153-2) by using color coded labels. This could also be done by working with the buyer assigned to purchase chemicals. The contract could be enhanced to require the supplier to add shelf-life to chemical labels. This could also reduce hazards associated with chemicals that have special storage requirements such as those that form explosive crystals and peroxidizers.
- Consider implementing a 6S program in labs. This program uses a simple system to improve efficiency and safety and reduce waste in the work area. Although it can be part of a Lean Manufacturing, Sigma Six quality program, it can also be very valuable as a stand alone process as demonstrated by an effort currently underway at SNL's Fleet Services.
- Evaluate chemical inventory systems to determine their applicability to organizations within Building 878.

- Consider other additions to the chemical contract such as requiring the manufacturer to accept expired and unused chemicals. This can be accomplished by working with the SNL Green Team buyer who is dedicated to including environmentally preferable options in all of SNL's contracts.

5.0 Individual Organization Descriptions

Each organization is described in the following sections. Each section includes a description of the organization, its waste generating processes, chemical management methods, best practices and suggestions for improvement. Figure 4 shows relative waste costs for each process.

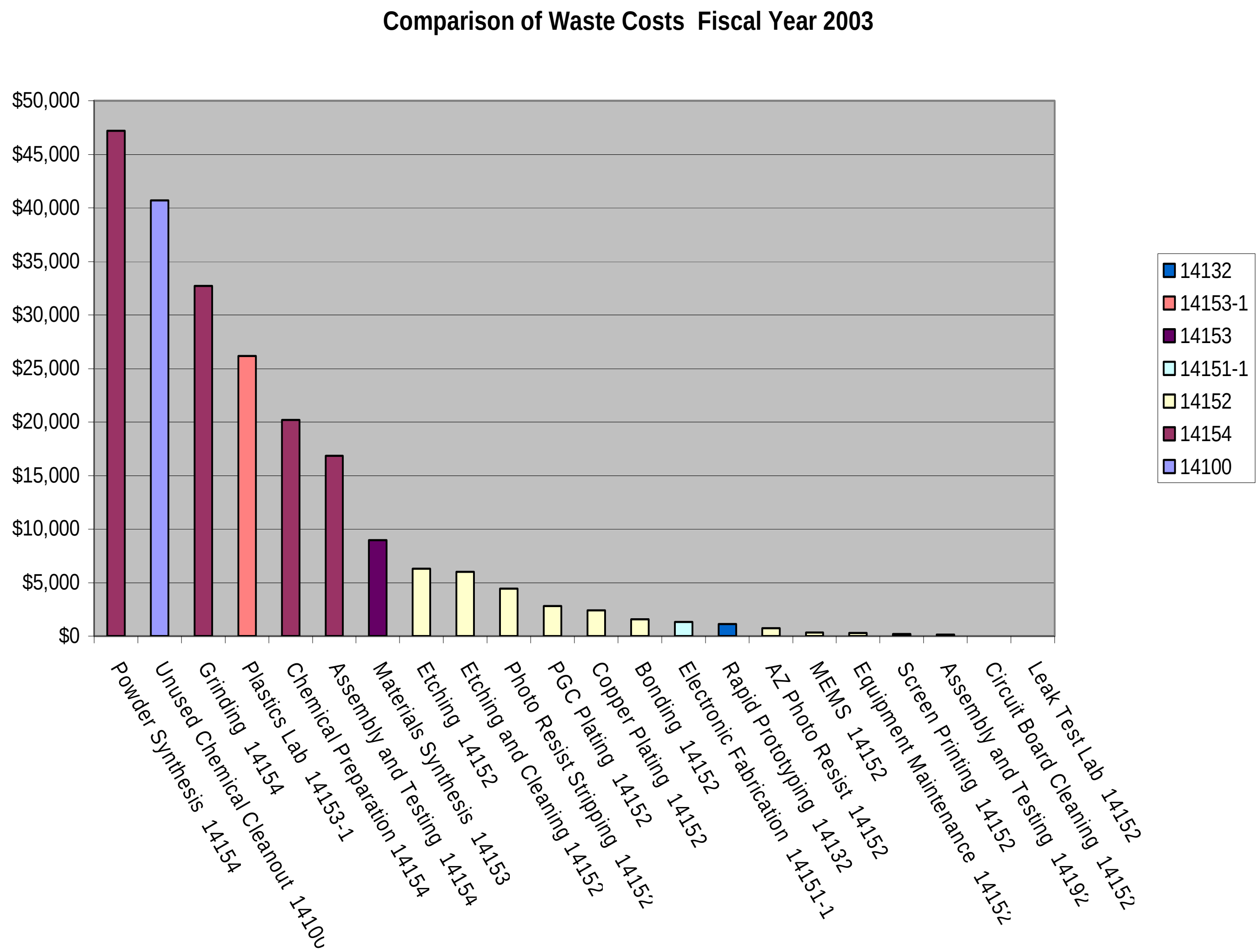

Figure 4 Process Comparison

5.1 Organization Number 14154 Ceramic and Glass Processing Department

The Ceramic & Glass Processing Department, Organization 14154, provides processing options for many types and compositions of prototype ceramic, glass, and glass-ceramic components. Activities range from chemical synthesis of powders and glasses, through powder processing, billet formation and machining, to complete component fabrication and testing.

As shown in Figure 4, this organization generates five out of the top eight costliest waste streams within Building 878. The processes within Organization 14154 can be divided into two general categories: creation of prototypes and R&D activities. Prototyping the processes can be further divided into the Powder Synthesis, Slug Pressing, Chemical Preparation, Grinding, and Assembly and Testing. R&D processes vary constantly and so wastes are difficult to track on a long term basis. Wastes from R&D process are not considered separately in this report.

Processes and Wastes

The main processes that take place in Ceramics are the manufacture of ceramic parts for WR processes. A lead oxide powder is processed into lead zirconium titanate (PZT) powder which is then pressed into what are known as "slugs."

Powder Synthesis

The synthesis of PZT powder involves creating a lead acetate solution by dissolving lead oxide in glacial acetic acid. This solution is then mixed with another solution containing titanium n-butoxide, zirconium n-butoxide, and niobium n-butoxide. The PZT is then precipitated to form an oxalate slurry. Propanol and other byproducts are then funneled off. This part of the process accounts for the majority of the liquid waste generated here. The PZT oxalate is then dried in an oven and calcined to form a crystal structure ready for pressing.

In the Ceramics lab, the processing of lead powder causes the powder to coat numerous surfaces. In order to eliminate potential employee exposure to lead in the powder, Personal Protective Equipment (PPE) is used consistently and can be used only once. It makes up one of the largest single waste streams in the building. Entrance into the lab requires hair covering, shoe coverings and gloves as well as lab coats. The lab is cleaned often with damp sponges and towels to reduce floating lead powder. Sticky mats are used at the lab exits to collect any lead from shoes. All of this material is disposed has hazardous waste because of the lead content.

All drains from the lab as well as those from the shower and Grinding empty into a collection tank located in the basement of the building. Water is allowed to settle and is filtered before being released to the sewer. The sump runs on flow meter so, whenever the final tank is full, the pump actuates and pumps the water through the filter system. The filters are replaced twice a year generating about 400 pounds of hazardous waste. There is also an undetermined volume of sludge in the bottom of the tanks which will probably require removal eventually.

Other wastes from powder synthesis include: lead oxide, glacial acetic acid, titanium, niobium, zirconium, n-propanol, n-butanol, ester species, oxalic acid, n-butoxide, acetyl acetate and alumina.

Slug Pressing

The next process involves pressing the PZT powder into slugs. The powder is granulated, pressed, and fired in two furnace cycles (bisque and high fire). Three density measurements are performed (after pressing and each firing cycle). Density measurements require PPE (gloves, and a towel or sponge for cleanup). The slugs are rinsed with deionized (DI) water and the rinsate is collected in the holding tank. Excess PZT powder is pressed into sacrificial slugs to increase the lead rich environment in the oven during the firing cycle. These slugs are then disposed as hazardous waste. The only other wastes are lead-contaminated PPE.

Chemical Preparation

The next step is chemical preparation of the slugs. The slugs must be washed in an aliquot of DI water and acetone. Acids and bases are used to adjust the pH before the slugs are calcined, vacuum processed, freeze-dried and fired.

Wastes include: acetone, nitric acid, hydrochloric acid, sodium hydroxide, oxalic acid, sodium oxalate, zinc chloride, manganese chloride, cobalt chloride, bismuth, and aluminum

Grinding

The grinding process involves grinding and sanding the ceramic slugs which are now called v-bars, prior to assembly. Because the v-bars contain lead, this work must be done under a hood using gloves. Epoxies are used to mount the v-bars onto a fixture for slicing and grinding. The v-bars are sanded to remove edges and then ground into their final shape. Solvents such as acetone and methanol are used to remove the parts from the mounting fixture. Cutting fluids used here become contaminated with lead and so must be disposed as hazardous waste. The parts are left in a bath of acetone to demount the fixture. The v-bars are then cleaned with acetic acid and a mixture of methanol and 2-propanol.

Wastes from grinding include: PPE, acetic acid, acetone, 2-propanol, methanol, WD-40, epoxies resins/hardener, lubricants, oils grease, coolants, Isocut, tensioning fluids, zinc oxide and Valtron primer. Often these materials are contaminated with lead making them hazardous waste.

Assembly

The final step is assembly and testing of the completed parts. The part is cleaned with acetone and alcohol after grinding. Then, silver epoxy ink is applied to the part for an electrical test. Silver is used because of its conductive properties. Acetone is used to remove the ink after the test. The main waste from this process is acetone contaminated with silver ink and the acetone and 3A used for cleaning the part. Other wastes from assembly include denatured ethanol and Fluorinert FC43. On rare occasions, lead-contaminated wastes can be generated.

Chemical Purchasing and Management

Powder Synthesis and Slug Pressing

Chemicals are purchased for powder synthesis activities by one person. Because of the lack of storage space, a creative solution was developed. Many of the chemicals needed for the year are purchased at one time. Fisher Chemical Company stores these purchased chemicals at their site until they are needed. Only a two month supply of chemicals is stored at SNL in various locations. There are few issues with chemicals exceeding shelf-life.

Chemicals routinely used in Powder Synthesis include glacial acetic acid, zirconium n-butoxide, titanium-butoxide, lead n-butoxide, oxalic acid (anhydrous), n-propanol, and litharge lead oxide powder.

The slug pressing process utilizes two, non-hazardous chemicals. One is HA4, a non-hazardous flocculent. The second is zirconium oxide powder (ZrO2) which is used to seal crucibles before firing. Neither has shelf-life issues and both are ordered in sufficient quantities to last several years.

Chemical Preparation

Chemicals used in the Chemical Preparation Process are ordered from the Fisher JIT contract and seldom vary. Certain chemicals must meet quality standards. It has been difficult for the program to find zinc chloride that meets quality standards so a large lot was purchased and is stored in another area. Chemicals are regularly rotated to ensure they are used within their shelf-life.

Grinding, Assembly and Testing

One person is in charge of maintaining adequate chemical stock for Grinding and Assembly and Testing activities. Chemical products are purchased through both Bonded Stores and the JIT contract. Shelf-life is tracked informally by the chemical purchasing person.

The most commonly purchased chemicals include: acetone, 2-propanol, 3A alcohol (a mixture of methanol, isopropanol and acetone) methanol, Solder Braze Alloy, Epoxy-Black Kit, abrasive powder, 7095 Silver Ink, conductive epoxy adhesive and conductive lacquer

Other chemicals purchased less frequently include acetic acid, WD-40, RF3503 AS Epoxy Resin, RF 619 Hardener, Valtron AD 3831 BR Epoxy Hardener, Valtron AD 8000 primer, Valtron AD 1210A and 1230A epoxy resin, Lapmaster Diamond Slurry, facsimile compound, Vactra oil, Mobile oil, Isocut fluid, TSK SE-1191 tensioning fluid, 321 Dry Film Lubricant, zinc oxide, Longlife 20/20 coolant, and Plews Multipurpose Grease.

Best Practices

- A green belt event held in 2003 developed a method to reduce acetone use by nearly 80%. During the process of ink removal the use of acetone was reduced from eight liters of acetone to one liter per lot. The organization process 8-10 lots annually so this represents a cost savings of $10,000 annually in product purchase, waste disposal and labor hours.

- One person orders chemicals, monitors shelf-life, and ensures all chemicals are barcoded.

- Acetic acid is reused as long as possible.

- Coolants used in Grinding are re-circulated as long as possible.

- The powder synthesis process uses soap with a high pH to neutralize water going to lead sump.

- The purchaser for Powder Synthesis found a significantly cheaper for lead oxide, saving the Center hundreds of dollars.

- Some chemicals used in the Powder Synthesis area are purchased at one time for the entire year. They are stored at the distributor's site until needed. This reduces chemical management costs and disposal due to outdated chemicals.

- A chilled cooling water loop was reconfigured to recycle water.

Potential Process Enhancements/Further Study

- Consider applicable suggestions in Sections 3 and 4.

- Follow up on the study already completed that indicates filtration of acetone used in Assembly and Testing could reduce disposal frequency.

- Consider filtration or ultrasonic cleaning for solvents used in Grinding.

- Consider hard plumbing chemical containers for use in the Powder Synthesis lab. This could reduce the cost of chemical purchases as well as management costs.

- Consider filtering coolants in Grinding to extend life.

- Consider modifications to the collection tank that collects water from Ceramics to reduce the amount of contaminants and sludge in the bottom of the tanks. Removing the sludge is difficult and expensive since it involves confined space entry and handling and disposal of lead contaminated sludge. Consider changes that would adjust the flow rate to reduce odor caused by stagnant water.

5.2 Organization 14153 Organic Materials, Lab B1000

Lab B1000 carries out a variety of organic and material synthesis, characterization and testing. The main waste generating process is the creation of polymers and inorganic crystalline materials. Chemical and waste management can be difficult within this lab for two reasons. First, all processes carried out in the lab are strictly R&D, making chemical procurement and waste generation difficult to predict and measure. The second is that the lab is shared with a number of other organizations who may not necessarily take responsibility for the management of their chemicals and waste. As shown in Figure 4, the lab (designated as its main process, Materials Synthesis in the figure) is the sixth largest waste generator in Building 878.

Processes and Wastes

Routine processes in the lab involve chemical synthesis and testing. Chemicals are stored in sample containers for testing. Often, the lab owner has to manage chemicals and wastes that are left by other lab or process owners. Sometimes these materials are not properly labeled and so handling and disposal can be difficult. For the past several years, the volume of waste from unused and "un-owned" chemicals was much greater than that from routine lab processes. Because of the routine nature of this waste, unused chemicals were counted in this lab's waste stream and not added to the waste stream labeled "Unused Chemicals" in Figure 4. Wastes from work process include: acetone, methanol, toluene, hexane, cadmium, barium, selenium, chloroform, bleach, mercury, cobalt disulfide, methylpolysiloxane, 1-hexadecylamine, polyethylene glycol, potassium hydroxide, propylene glycol, pyridine, tetraethylorthosilicate, tetrahydrofuran, zinc acetate, and vacuum pump oil.

Chemical Purchasing and Management

Chemicals are stored in a community cabinet. Everyone who uses the lab utilizes similar solvents such as acetone and toluene and the costs are not distributed. Chemicals are purchased as needed and there is no list of regularly purchased chemicals. The CIS tracking system works well for this organization and it is thought that any additional inventory systems would be too cumbersome.

Best Practices

- One person is in charge of the lab space and encourages lab users to properly manage their chemicals.

- A thorough chemical clean out took place last year and more attention is being paid to management of chemicals and waste within the lab.

Potential Process Enhancements/Further Study

Improve controls in B1000 to ensure all users are responsible for their own chemicals and waste. The following enhancements are suggested:

- Evaluate the service work guidelines and enforce them. Develop a mandatory check-in/check-out process for each person who uses the lab. Chemicals and samples should be barcoded with the name of the user not just the lab owner.

- Develop a special training to be required for all students, new hires and lab users from other organizations. The training would focus on chemical management including proper labeling and waste reduction and disposal techniques.

5.3 Organization 14153-1 Plastics Lab

The Plastics Lab, Department 14153-1, provides prototype fabrication, materials technology and materials testing. It encompasses 9 labs and a machine shop and employs about 12 people. The entire department is a service organization that carries out mostly classified work for SNL and other customers. WR work makes up about 20% of the Lab's work load.

Processes and Wastes

There are five main waste generating processes carried out in Plastics: adhesives, encapsulation, coatings, composites and prototype work for the NGF. Most processes focus on R&D and require a rapid turnaround. Because of this and the variety of projects, Plastics must maintain a large stock of equipment and chemicals on hand. In some cases work is scheduled just two weeks in advance and priorities often change depending on customer needs.

In general, customers are not charged for waste since it is thought that this may decrease competitiveness. However, for some large, irregular orders with unusual types or volumes of waste, customers are charged for waste.

Wastes include: PPE, both dried and unreacted epoxies, acetone and ethanol from cleaning processes, diisocyanates, silver epoxy, silicone resin, cutting oil and other lubricants, and various fiberglass and foam components. As shown in Figure 4, the lab is the fourth largest waste generator in Building 878.

Chemical Purchasing and Management

Most chemicals are purchased from Fisher through the JIT contract. Because of the rapid turnaround required by customers, a variety of chemicals have to be stocked in large quantities. Customers specify procedures to be followed and chemicals to be used. Many of these chemicals are epoxies and have a very limited shelf-life. Over fifty different types of epoxies are used as well as other materials. If the Plastics Lab does not use up the entire chemical, the remainder must be disposed when shelf life is exceeded. This is the major factor contributing to the Lab's high level of waste generation.

Shelf-lives for many chemicals used in the Lab are only six months to a year. Because of this, manufacturers may make only 200 gallons of any one material at certain times during the year making some of these chemicals difficult to obtain quickly. The lab has had great success working with the Fisher chemical representatives who are often able to find difficult to locate chemicals on short notice.

The lab is currently involved in a year-long process of disposing of old, unused chemicals. They have added new controls to reduce the likelihood of chemicals going out of shelf life. A color-coded labeling system was implemented that includes purchase date, purchaser, and shelf life.

This ensures a “first-in, first out” usage which reduces the likelihood that materials will expire before use.

Chemical ordering is rotated among eight employees for a three month period. This ensures that all employees are cross-trained on ordering and that they have an awareness of the requirements for chemical management. When new chemicals are needed they are added to a list on a board for the designated employee to order. According to the lab manager, a computer based inventory system could be extremely valuable. Currently, chemicals stocks are checked on an informal basis by hand. An electronic system could improve scheduling and buying.

Best Practices

- The lab has instituted an improved process for chemical management. Monitoring shelf life and having a first in first out policy helps ensure that chemicals can be used for their intended purpose and do not have to be disposed.

- The plastics lab has instituted a good energy saving policy for the vault. The last person leaving for the night is required to ensure all lights are out.

Potential Process Enhancements/Further Study

- Work with JIT or manufacturers to improve supply of epoxies to reduce shelf-life issues.
- Consider ultrasonic cleaning.
- Consider filtration to increase the life of solvents.
- Consider alternatives to extend the life of cutting fluids.
- Consider laundering of PPE.

5.4 Organization 14152 Thin Film, Vacuum and Packaging

The Thin Film, Vacuum and Packaging Department 14152 works with the Center’s partners who require thin film engineering, vacuum system design and fabrication, brazing, as well as electronic module manufacturing and packaging technologies.

Processes and Wastes

<u>Screen Printing</u>

The screen printing process applies one or more of several types of inks onto ceramic substrates to create a foundation for circuit boards. The ink is deposited through an eight by ten inch screen. The substrate may then be dried and fired if conductor ink is used. Other layers may be added depending on the customer’s design requirements. A lead-containing pre-cursor to ceramic known as “green tape” may be applied as well. Solder paste is used occasionally if additional components are added to hardware. The ceramic substrates are then cleaned by hand or sometimes in ultrasonic tank. Propanol and a lint-free wiping rag are used to clean this screen approximately three times per day.

Wastes from screen printing include: rags contaminated with propanol and ink, lead solder, oil, green tape, platinum, gold, terpenes, and toluene.

Etching and Cleaning

The chrome etch process involves cleaning shielding from evaporators. The shielding is placed in a tank of Cyantek ES-1 chromium etchant. The piece is then removed from the tank and rinsed with DI water. The pieces are dried and cleaned with trichloroethylene (TCE). The parts are then wiped with alcohol and dried again. They are fired in two separate processes and returned to the evaporator. Wastes include acids containing metals, hydrofluoric acid, hydrochloric acid, nitric acid, TCE, and alcohol. The ceramic and glass cleaning processes involve several steps that generate waste. The substrate is ultrasonically cleaned in a beaker of acetone. It is placed in a series of DI baths, some with soap. Finally, it is placed in a beaker of boiling 15% hydrogen peroxide solution, rinsed and blown dry. The final step for ceramic parts is oven firing. Copper and steel cleaning is similar to the above described processes and generates TCE, acetone, and alcohol.

The copper plating bath is used infrequently. Spent plating solutions containing acids and copper are the waste streams.

AZ Photo Resist

During the photo resist process, a platable, photo resistant chemical called PEPR 2400 is mixed with water and placed in a beaker. The part to be tested is added to the beaker and voltage is applied to attach the colloids in the PEPR to the part. The parts are tested and then the photo resist is removed from the part using acetone. Wastes from this process include PEPR 2400 a sodium carbonate developer (which can be disposed in the sanitary sewer), and acetone.

Photo Resist Stripping

Waste chemicals from the photo resist stripping and developing process include acetone, IPA (a mixture of isopropyl alcohol and methanol), n-methyl-2 pyrrolidone (NMP), a developer containing propylene glycol monomethyl ether acetate (PGMEA) developer, AZP 4000, and Clarient SU8. Other materials include aluminum foil, wipes, and syringes contaminated with PMEA and AZP 4000.

Etching

The etching process is used to remove several substrates including a sacrificial glass layer that is used to protect parts. Parts are etched using variety of mixtures including hydrofluoric, sulfuric, nitric, glacial acetic and hydrochloric acids, hydrogen peroxide, and ferric chloride An ink is painted on the part to protect it from etchants in the bath. After the part is removed from the etchant bath, the ink is removed with acetone and rinsed in IPA. NMP is used to remove ink that is resistant to the acetone. This process is seasonal and sporadic and involves small volumes (usually 500 milliliters or less). Solutions are usually kept for six months or more. Last year, only five gallons of etchant were disposed.

Potassium Gold Cyanide (PGC) Plating: This process consists of an 8 liter bath of plating solution (DQuest 2000 and potassium hydroxide) in a glass battery jar. It is only used once every one or two years. Wastes include rags, syringes, bottles, and spent plating solutions.

Micro Electronic Mechanical Systems (MEMS) Testing lab generates approximately one liter of waste per year. The wastes include methanol, acetone, green tape, gloves and rags.

Circuit board cleaning generates approximately 5 gallons of waste per year which is mainly composed of BioAct EC7 and terpenes. Other materials include solder flux, and solder scraps containing tin, lead, antimony, and indium.

The Hydrostatic Laminator is used infrequently and generates ethylene glycol.

The Laser Lab generates green tape.

Bonding generates Ablebond 8175A, propanol, acetone, silver epoxy, JM7000, rags, gold.

The Leak Test Lab generates Flourinert A-710, Cerinium Oxide, and Beryllium.

Hybrid Assembly generates lead solder, iridium, flux, green tape, propanol, and methanol.

Nickel Plating requires a plating chemical called Woods Nickel Strike. Wastes include nickel chloride and hydrochloric acid.

Chemical Purchasing and Management

Because most chemicals are used quickly, they are purchased in small quantities. TCE is an exception. It is purchased in a 55 gallon drums since it doesn’t expire. Recent improvements to chemical management include highlighting expiration dates on labels. Lab personnel get unused chemicals from the Hazardous Waste Technician to avoid buying new chemicals wherever possible.

Best Practices

- Precious metals are recovered whenever possible.
- Shelf-life is highlighted on chemical labels to help reduce disposal due to expired material.

- Personnel in Screenprinting reuse chemicals in the ultrasonic bath where possible and rags are used as long as possible before disposal.

- Personnel in Etching and Cleaning use excess chemicals from other labs in 878 whenever possible.

Process Enhancements Recommended for Further Research

- Consider applicable recommendations from Sections 3 and 4.

- Consider replacement for hydrofluoric acid because of its extreme toxicity. Evaluate the relative safety of using weaker but heated acids.

- Consider replacement for TCE.

5.5 Organization 14132 Manufacturing, Engineering and Process Development

The Manufacturing, Engineering and Process Development Laboratory (RPL) supports internal design, manufacturing, and process development with three RP technologies: stereolithography (SL), selective laser sintering (SLS), and 3D printing (3DP). Manufacturing, Engineering and Process Development uses advanced computer and laser technologies to produce complex three-dimensional prototypes and is located in Lab Y352. It employs about 5 people.

Description of Main Waste Generating Processes and Activities

As shown in Figure 4, Organization 14132 generates a relatively small portion of the Center's waste. Most of the waste is considered non-hazardous.

The SL technology uses an ultraviolet laser to cure thin layers of epoxy photo-polymer into precise forms. SL is used for a variety of tasks including the manufacture of models for design reviews and fit-check tests, and to create functional parts and patterns for castings. Wastes include epoxy resin and Dowanol solvent.

SLS is used to fabricate functional parts from a nylon-based powder known as DuraFoam PA. The parts include pattern masters, conceptual models, fit check models, and mandrels. The SLS technology uses a carbon dioxide laser to fuse powdered polymer cross sections in a layer additive fashion. Wastes include gloves, polyamide powder, ethanol, and ethylene glycol.

The 3DP technology uses ink-jet heads to print binder to fuse powdered polymer or ceramic cross sections in layers. This system prints in full-color, communicating information about parts, including engineering data, labeling, highlighting and appearance simulation. Ink and water are generated from this process. This is the labs largest hazardous waste stream.

Chemical Purchasing and Management

The lab purchases few chemicals. Shelf life is an issue with the epoxy and binder ink and so it must be monitored by lab personnel. Sometimes personnel offer free printing to use up ink that is about to exceed shelf-life. Epoxy is photo sensitive and needs laser light to cure. Resins don't have a shelf life.

Best Practices

The lab offers free printing to use up ink if it is about to exceed shelf life.

Process Enhancements Recommended for Further Study

- Consider applicable recommendations from Sections 3 and 4.

SL Process

- The addition of a sonic bath to clean parts could eliminate 40-50 pair of gloves a day and reduce use of TPM Dowanol solvent by approximately 40%.

- Improve coordination of ink purchases with jobs could reduce disposal due to expired shelf-life.

SLS Process:

- Currently, the DuraForm powder is mixed in an open container. Approximately one bucket of powder is lost annually through fugitive emissions during the mixing process. This lost powder is worth approximately $2500. Loose powder is also a safety issues since it is slippery. The room is shared with another organization and the powder can contaminate their work areas as well. An enclosed container, similar to a cement mixer, could save this much annually.

- The SLS machine is antiquated (ten years old). Because of its age, the machine breaks frequently and doesn't operate at its optimum performance. Because of this, parts or "cakes" often do not meet specifications and must be disposed. This loss is equivalent to three buckets per year of powder, which at $2500 per bucket equals $7500 annually plus wasted labor hours. Because the machine is so old, parts have to be replaced continuously. This year, replacement parts and installation cost the Center $17,000. Finally, the parts are not longer being manufactured for this machine. The last computer part had to be scavenged from an old computer and retrofitted. The machine is nearly obsolete. Purchasing a new center station may be a cost effective solution to these issues.

5.6 Organization 14151-1 Electronic Fabrication

Electronic Fabrication, Department 14151-1, partners with customers, primarily Sandia engineering staff, in the partial and complete development of specialized electronic systems. These labs carryout cable assembly, chassis assembly and PC board assembly.

Description of Main Waste Generating Processes and Activities

As shown in Figure 4, this lab is one of the smaller waste generators in Building 878. Processes in these labs can be divided into three main categories: 1) chassis assembly, 2) cable assembly, and 3) PC board assembly.

Chassis assembly begins with the layout and cutting of boards. Boards are inked by hand using 3084 F Rapid Draw ink or engraved, depending on customer requirements. Inked boards are coated with clear lacquer and engraved boards are coated with Engraver's Enamel Gloss. The chassis are then soldered. Most waste is generated from cleaning after the soldering process. The chassis must be dipped in a propanol bath to remove flux and other soldering contaminants. Cable assembly requires cutting of wires and soldering. Again, the cables must be cleaned using a propanol bath before and after soldering. PC board assembly occurs sporadically. It is similar to chassis assembly and requires the same propanol cleaning bath.

Wastes include spent propanol, soldering ends (which are collected for recycle), epoxy waste, and aerosol cans of lacquer and cleaner.

Chemical Purchasing and Management

One person orders all chemicals for both labs. Commonly ordered chemicals generally come from Fisher and include propanol, lacquer and epoxy products. An epoxy called Tracon is dated and expires quickly. Because rates of use are unpredictable, the product sometimes exceeds its shelf life and must be disposed. This may be alleviated by ordering directly from the manufacturer.

Best Practices

- Personnel in A600 made special signs to help people dispose of hazardous waste in the correct disposal containers. There are three containers; one for dried epoxy, one for unreacted epoxy and one for containers that need to have barcodes removed. The signs include instructions regarding aerosol cans, epoxies and other waste.

- Signage is supplemented with a 15 minute training to remind lab personnel of the importance of proper disposal of waste.

- Personnel collect solder waste for recycle.

- When chemicals arrive without barcodes, lab personnel apply the barcodes and take the containers to the Hazardous Waste Technician to be entered into the CIS system.

Potential Process Enhancements for Further Study

- Consider applicable recommendations in Sections 3 and 4 especially refillable aerosol cans, ultrasonic cleaning, and filtering propanol for re-use.

- Consider working with manufacturers of Tracon and other epoxies to improve shelf life issues.

6.0 Conclusion

Personnel within organizations within Building 878 are, for the most part, aware of waste costs and continuously searching for ways to reduce those costs. Opportunities identified and implemented from this report will enhance operations within the building.

Documentation and evaluation of waste generating processes can be found in Appendix 4.

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Appendix 1
Waste Management Improvements

Current Waste Management Activities
In
Center 14100

By Max Saad
Division 14000 Environmental Protection Representative

Waste Profiling

Over the last couple of years, the SNL/NM Legal and the Regulatory Compliance Departments have allowed organizations like Center 14100 to "profile" certain waste streams as non-hazardous that were previously managed as hazardous. This profiling process allows wastes to be removed from the RCRA regulatory requirements and be disposed of as solid waste. The profiling process requires that both the Environmental Protection Representative and the Facility Hazardous Waste Technician demonstrates that a waste stream does not meet the characteristic or listed criteria of a hazardous waste.

In the second quarter of FY03, several waste streams were profiled out of the waste management system. This reclassification process reduced the amount of hazardous waste generated within Center 14100 by almost 25%, and saved over $30,000 this year in disposal costs.

Profiled waste streams include:

- ✓ Rags and wipes contaminated with solvents. This facility was generating over 30-gallons a week of dry solvent contaminated wipes. An evaluation of each generator's processes was reviewed along with a basic training session on the regulatory guidelines for the disposal of these rags.
- ✓ Oily contaminated material. Daily, weekly and monthly preventative maintenance programs generate large amounts of this waste stream.
- ✓ Epoxy/Resin contaminated Lab Trash – rags, gloves, wipes, and cotton swabs contaminated with all types of epoxy and resins, with no free liquids. The Plastics and Electronics laboratory was generating over 30-gallons a week of this material. An evaluation of each generator's processes was reviewed along with a basic training session on the regulatory guidelines for the disposal of this material.
- ✓ Vacuum System Dust – This was a waste stream that generated ten (10) 55-gallon metal drums of vacuum dust from clean-up activities in the machine shop. This waste stream was profiled out of the waste management system and this material is taken directly to the Solid Waste Transfer Facility (SWTF) for disposal.

Waste Compactor

A compactor for the management of slightly contaminated compactable materials was recently installed. This compactor was purchased to reduce the time for the handling and packaging of each bag of material as well as to reduce the costs for the disposal of this waste stream. Presently, the Center 14100 generates about ten bags a week of this type of material. This compactor has the capability to compact these 10 bags of material into one metal 55-gallon drum which is cheaper to dispose than smaller containers.

Waste Bulking

One of the largest waste streams that is managed from Center 14100 are five gallon containers of waste. These containers weigh about forty pounds and can be corrosive, flammable or non-regulated but are required to be managed through the Hazardous Waste Management Facility (HWMF) at a cost of $2,000.00 per container. Each year, Center 14100 spends close to $200,000 for the disposal of these types of waste. The largest hazardous waste stream in Center 14100 is a spent corrosive solution from the Ceramics area. Another significant waste stream is spent solvent used throughout the facility for cleaning and degreasing. On September 1st 2003, the Hazardous Waste Technician started bulking solvent wastes, corrosive and non-hazardous waste stream from building 878. By bulking these waste streams Center 14100 is estimated to save almost $8,000.00 per drum. This is expected to save at least $100,000 per year.

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Appendix 2
Reusable Aerosol Containers and Suppliers

Samples of Reusable Containers Currently on the Market

Company/Location	Type of Container/Product	Web Address	Telephone
Milwaukee Sprayer Manufacturing Company, Inc. Milwaukee, WI	Aerosol can substitute for cleaners, degreasers, penetrating oils, solvents and lubricants	http://www.sureshotsprayer.com	1-800-558-7035
Inland Technology 401 East 27th Street Tacoma, WA 98421	Aerosol can substitute for solvent applications	http://www.inlandtech.com	(800) 552-3100 (253) 593 8749
Stark & Associates Charlotte, NC	Plastic containers		(704) 332-5004
Impact Products	Plastic containers	http://www.impact-products.com/	(419) 841-2891
Tolco Corporation	Plastic containers	http://www.tolcocorp.com	(800) 537-4786
Zep Mfg. Company	Bulk cleaning product	http://www.zepmfg.com	(408) 739-3656
Aubuchon Hardware	Bulk WD40	http://www.aubuchonhardware.com/brands/wd40_co-tom_bland.asp	

Sample List of Suppliers of Reusable Containers

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Appendix 3

Sample of Laboratory Specific Pollution Prevention and Waste Management Training Module

This is a sample lesson plan outline for use by the instructor.

Pollution Prevention and Waste Management Training

Module Sample

Determine which of the following list of suggestions applies to the lab and discuss each, using specific processes and chemicals found in that lab.

Pollution Prevention Considerations in Chemical Purchasing

- Before purchasing a chemical, determine if other labs may have excess quantities of the chemical. Giving the chemical to you could be more cost effective for them since they can avoid disposal costs.

- Purchase chemicals through Fisher when possible. These chemicals are barcoded for tracking in the Chemical Information System (CIS). When purchasing non-Fisher chemicals, obtain a barcode from the Hazardous Waste Technician and have it put into the CIS. Explain the importance of chemical tracking including safety, efficiency and waste management.

- When purchasing a chemical that has not been used in your lab before, notify the ES&H coordinator to ensure proper management controls are in place for that chemical.

- Eliminate the purchase of aerosol cans wherever possible. In many cases aerosol nozzles fail, leaving material in the can. Each non-empty aerosol container must be disposed as hazardous waste. The purchase cost of the contents of the can is also more expensive than similar materials not in aerosol form. Refillable aerosol containers reduce disposal cost and purchase cost since material can be purchased in bulk.

- Consider consolidating chemicals by limiting brands wherever possible. Different brands that serve the same purpose could be eliminated thereby providing improved efficiency and purchase prices through standardization.

- Consider adding shelf life to all chemical labels and implementing a tracking system that flags all chemicals that are about to exceed shelf life. This is already being done in the Plastics Lab (Organization 14153-2) by using color coded labels.

- Adopt a “first in, first out policy; that is, use older chemicals first.

Pollution Prevention for Daily Laboratory Procedures

Cleaning

- Avoid using fresh solvents for cleaning glassware. Filter and re-use solvents for this purpose or use Alconox and elbow grease.
- Use quaternary amine detergents instead of isopropyl alcohol for sterilizing equipment. Always consider hot water and detergent.
- Use ultrasonicators instead of solvents for cleaning.
- Purchase better brushes to reduce the temptation of opting for a solvent for cleaning.
- Keep extra glassware on hand and/or use drying oven to reduce need for rinsing with solvent to hasten drying of glassware.
- Minimize the amount of cleaning solution used. If water is the cleaning agent, use sprays or jets of water to clean tanks for equipment. Where possible, the small amount of concentrated waste collected should be recycled as a raw material. Rinse machinery and tanks less often.

Process Changes

- Replace wet tests with analytical instrumentation or virtual applications whenever possible.
- Neutralize acids and bases wherever possible. Perform chemical conversions on left over chemicals to create non-hazardous substances. Consider methods for deactivation, oxidation using bleach, precipitation and reduction to yield a less toxic waste. Before implementing any treatment procedures, notify your ES&H coordinator. In some cases a simple notification may be required prior to treatment.
- In new, experimental procedures where only small quantities of chemicals will be required, consider using chemicals from other labs before purchasing new chemicals.
- Eliminate or reduce mercury compounds. Mercury has become extremely expensive to manage and dispose. A mercury spill can cost thousands of dollars in clean up and disposal costs because of the regulatory requirements involved required when handling mercury. If a mercury compound is specified for a procedure, consider such substitutes as copper sulfate and consider reducing the scale of the procedure to reduce the amount of mercury used and disposed. Minimize the volume of waste generated by including precipitation or other treatment methods as the last step of the procedure.
- Eliminate the use of mercury thermometers. This has already been accomplished in all the research labs within Organization 1800.Replace with digital or alcohol/glycol thermometers. For differential manometers, use water or calibrated oils instead of mercury or switch to pressure transducers or electronic pressure gauges.

- Maximize dedication of process equipment. This can reduce equipment cleaning frequency and waste generated.

- Filter or distill waste solvents and regenerate catalysts wherever possible

- Transfer liquids by means of pumps and piping systems rather than by hand. This can reduce the chances of spillage.

- Consider product reformulation. For example, preparing chemicals in pellet form instead of power can reduce dust emissions.

- Review the use of highly toxic, mutagenic, and peroxidizing chemicals and determine if safe alternatives are available. See the Figure A1 for examples.

Instead of....	**Try…**	**Uses**
Acetamide	Stearic Acid	Phase Change Freezing Point Depression
Benzene	Hexane Ultrasonic Baths	Many Solvent uses
Chromic acid	Alconox Ultrasonic Baths	Glass ware cleaning
Isopropyl alcohol	Quaternary amine detergents	Sterilizing
Halogenated solvents	Non-halogenated solvents Sonic baths	Some extractions and cleaning

Figure A1

Housekeeping

- Keep storage and work areas clean and well organized and keep all containers properly labeled.
- Keep all containers covered to prevent evaporation, spillage, or drying out of contents.

Waste Management

- Discuss each waste stream from this lab. Describe how it should be disposed. Include the following instructions and lab specific examples for each of the following types of waste:

  Keep waste streams separate for reuse, recycling, or treatment.

  Keep non-hazardous materials from becoming contaminated with hazardous waste.

Keep hazardous waste separate from non-hazardous waste.

Keep organic waste separate from inorganic waste.

Keep different groups of solvent separate (e.g., halogenated vs. non-halogenated solvents).

- Discuss costs of hazardous waste. (Provide an example of a commonly disposed item from the lab and quote the disposal cost. Aerosol cans are a good example. See discussion under chemical purchasing.)
- When buying new equipment, look for equipment that will minimize both the amount of toxic materials used and the amount of waste produced. (Prior to giving the training, identify an example from this or another lab in 878.)
- Involve employees in designing and implementing waste reduction measures. Establish incentives to encourage workers to use waste reduction techniques and to suggest changes in design or operating procedures that would further reduce waste generation. Set goals for waste and energy reduction within each lab. (Discuss ways this could be accomplished in each specific lab.)

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Appendix 4
Summary of Pollution Prevention Options and Evaluation

Option	Implement Now	More Research	PPOA	No Further Action	Discussion
Institute centralized ordering and receiving for chemicals.	X				
Characterize recurring waste streams using laboratory analysis.	X				
Track waste by process i.e., lab, and send monthly chargeback reports showing the costs of waste to the lab owners.	X				
Replace mercury-containing thermometers with digital or alcohol/glycol thermometers.	X				
Track unused chemicals that are disposed and make reducing them a management priority.	X				
Require notification for new chemical, sample and non-Fisher purchases and have them sent through centralized system.	X				
Consider adding shelf life and purchase dates to all chemical labels. Implement a first in first out policy in each lab.	X				
Evaluate chemical inventory systems to determine their applicability to organizations within Building 878.	X				
Organization 14153 B1000 Lab: Improve controls in lab to improve accountability and management of chemicals.	X				
Organization 14152: Recycle solder scraps from Screen Printing	X				
Organization 14132: Purchase an enclosed powder mixing device for Rapid Prototyping.	X				
Organization 14132: Ultrasonic bath for SL process.	X				
Organization 14132: Improve shelf-life monitoring and ordering for ink for 3D printer and epoxies.	X				
Evaluate all processes using solvents and consider aqueous based ultrasonic cleaning, filtration, and/or distillation.		X			This evaluation would be on a case-by-case basis.Customers resist alternative solvents. Maybe applicable to R&D work but more difficult with outside customer requirements.
Evaluate the advantages of attaching waste costs to service orders.		X			In most of the Center's organizations, waste is considered an overhead cost and is not accounted for when considering cost estimates to customers. Allocating waste costs could allow the Center to determine the true cost of serving each customer so that it can price its services more effectively.

Option	Implement Now	More Research	PPOA	No Further Action	Discussion
Include a process diagram in each organization's eTWDs and SOPs.		X			Include a general description including constituents and volumes of wastes from each process. Any new processes, wastes or process changes would require a change to this documentation. Require for any new processes. This type of evaluation and documentation is consistent with SNL's proposed method of meeting the requirements to have an EMS in place by 2005.
Neutralize corrosive wastes.		X			This option has been studied in the past and was found to be problematic for a number of reasons. Often the wastes contain metals such as copper and zinc would prevent disposal in the sanitary sewer without further treatment such as precipitation and removal of the metals. This was deemed to be too time consuming by lab personnel. Many of these waste streams are extremely corrosive and may not be amenable to neutralization due to hazards associated with this process. An analysis of each waste stream will be completed to determine the feasibility of neutralization on a case by case basis.
Eliminate aerosol containers wherever possible particularly WD-40. Use refillable containers.		X			Use of aerosols must be evaluated on a case-by-case basis. This should be considered because of high disposal costs for aerosols.
Consolidate chemicals by limiting brands wherever possible.		X			For example, numerous different types of epoxies are used. By compiling a list of epoxies and their performance requirements, one brand that works for many purposes could be identified. Different brands that serve the same purpose could be eliminated thereby providing improved efficiency and purchase prices through standardization.
Consider additions to the chemical contract such as requiring the manufacturer to accept expired and unused chemicals.		X			This can be accomplished by working with the SNL Green Team buyer who is dedicated to including environmentally preferable options in all of SNL's contracts.
Consider implementing a 6S program in labs.		X			This program uses a simple system to improve efficiency, safety and can often reduce waste in the work area. Although it can be part of a Lean Manufacturing, Sigma Six quality program, it can also be very valuable as a stand alone process as demonstrated by an effort currently underway at SNL's Fleet Services.
Consider other additions to the chemical contract such as requiring the manufacturer to accept expired and unused chemicals.		X			This can be accomplished by working with the SNL Green Team buyer who is dedicated to including environmentally preferable options in all of SNL's contracts.
Organization 14154: Follow up on the study already completed that indicates filtration of acetone could reduce disposal.		X			May not be cost effective.Filters may be more expensive than return.

Option	Implement Now	More Research	PPOA	No Further Action	Discussion
Organization 14154: Consider modifications to the Lead Settling tanks to reduce the amount of contaminants and sludge in the bottom of the tanks.		X			Removing the sludge is difficult and expensive since it involves confined space entry and handling and disposal of lead contaminated sludge. Consider changes that would adjust the flow rate to reduce odor caused by stagnant water.
Organization 14152: Consider replacement of HFl Acid.		X			Amounts are small but hazard is great. One alternative is heating weaker acids to achieve the same level of cleaning.
Organization 14153-1: Plastics Lab			X		Schedule PPOA
Consider replacing silver based ink with copper in Assembly.				X	WR requirements are too difficult to change. Gain deemed not worth the effort.
Grinding coolants and others to machine shop for evaporation.				X	Coolants are contaminated with PZT.

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